International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 8, Issue 1, Feb 2018, 471-478

CHEMICAL AND WATER ABSORPTION BEHAVIOUR OF HARDWICKIA BINATA FIBER REINFORCED COMPOSITES

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ABSTRACT

In recent years Natural fiber reinforced polymer composites have been used in the engineering applications. Composite materials possess high strength to weight ratio, and due to these facts composite materials are becoming popular among researchers and scientists. The major proportion of engineering materials consists of composite materials. Natural fiber reinforced green eco-friendly composites made from jute, hemp, sisal, banana, coir, green bagasse from the natural sources provide indisputable advantages over synthetic reinforcement materials such as low cost, low density, non-toxicity, comparable strength, and minimum waste disposal problems. In the present work, natural fiber Hardwickia Binata was introduced and composites were prepared varying fiber loading like 5%, 10%, 15% and 20% using hand lay-up process. Water absorption and chemical resistance properties were examined for the fractured fibers. Scanning electron microscope (SEM) analysis is carried out and analyzes the structure of the fractured surfaces after water absorption

KEYWORDS: Natural Fiber, Composites, Hardwickia Binata, Chemical Absorption, Water Absorption & SEM

Received: Nov 30, 2017; **Accepted:** Dec 20, 2017; **Published:** Jan 10, 2018; **Paper Id.:** IJMPERDFEB201852

Original Article

INTRODUCTION

Natural fibers are renewable, non-abrasive, and bio-degradable possess a good strength, exhibit excellent mechanical properties and are inexpensive. This makes the materials very popular in engineering applications such as the automotive and construction industry. Natural fibers are considered as environmentally friendly materials which have good properties compared to synthetic fiber [1,2]. The use of natural fiber from both resources, renewable and nonrenewable such as oil palm, sisal, flax, and jute to produce composite materials, gained considerable attention in the last decades, so far. The plants, which produce cellulose fibers can be classified into bast fibers (jute, flax, ramie, hemp, and kenaf), seed fibers (cotton, coir and kapok), leaf fibers (sisal, pineapple, and abaca), grass and reed fibers (rice, corn, and wheat), and core fibers (hemp, kenaf, and jute) as well as all other kinds (wood and roots) [3]. NFPCs with a high specific stiffness and strength can be produced by adding the tough and light-weight natural fiber into polymer (thermoplastic and thermoset) [4]. Different factors can affect the characteristics and performance of NFPCs. The hydrophilic nature of the natural fiber and the fiber loading also has impact on the composite properties 5]. The effects of jute fiber on the mechanical properties of pure biodegradable polymer (Biopol) and the mechanical properties of the resulted composites, impact strength, tensile strength, and bending strength, showed an increase when compared with pure Biopol. The tensile strength of jute Biopol was enhanced by 50%, while bending strength and impact strength of the composites were enhanced by

30%and 90% in comparison to pure Biopol. NFPCs are such composites whose mechanical efficiency is dependent upon the interface provided by fiber-matrix along with the stress transfer function in which stress is transferred to fiber from matrix. This has been reported by many investigators in several researches [6,-, 8]. Characteristic components of natural fibers such as orientation, moisture absorption, impurities, physical properties, and volume fraction play a constitutive role in the determination of mechanical properties [9-13]. Bagassee polyester composites were prepared by addition of 5, 10 and 15% of untreated and alkali treated bagasse fibers to polyester, flexural behavior of the prepared composites was studied, water absorption and chemical resistance were conducted showing that the produced bagassee polyester composite with appreciable mechanical and physical properties is a new partner and cost effective material for many advanced industrial applications in addition to their environmental friendly behavior[14]. Rajulu outlines the chemical properties of natural fibers composites and discusses the latest trends in chemical modification mechanisms [15]. Guduri used uniaxial natural fabric of Hildegardia populifolia as reinforcement for a polycarbonate toughened found to have reasonable chemical and water resistance [16]. Jayaramudu used Polyalthiacerasoide woven fabrics as reinforcements of epoxy and these hybrid composites showed resistance to acids, alkalis and various solvents and also possessed lower water absorption [17].

In the present research the newly identified Hardwickia Binata Fiber obtained from the trees which are grayish brown in colour, rough with deep cracks and it darkens with age [18]. The compound leaves have only two leaflets which are joined at the base. The common name of hardwickia Binata Plant is Anjan or Narepa which belongs to the family “caesalpiniaceae” native to tropical and subtropical regions [19, 20]. In the present study composites were fabricated by hand layup process varying fiber loading and chemical resistance and water absorption properties were studied at 20% fiber loading where maximum strength was found for the fractured fiber composites. Finally it is suggested that Hardwickia binata fiber as an eco-friendly green composite and also used as an alternative for synthetic fibers.

MATERIALS AND METHODS

Materials

In the present investigation, Hardwickia Binata fibers are used for the preparation of the composites. Fiber collected from the bark of trees are extracted through retting process is treated with NaoH. Processed fiber is supplied by Natural fiber suppliers, Guntur. Physical properties of the fiber were mentioned below in Table1. Epoxy resin type: Araldite LY-556 and hardener HY-951 as the matrix components, polyvinyl alcohol (PVA) is used as mould releasing agent, glass moulds are used for fabrication and the mould cavity is coated with a thin layer of aqueous solution of PVA for easy removal of the sheet from the mould.

Table 1: Physical Properties of Hardwickia Binata Fiber

Physical Properties Hardwickia Binata Fiber	
Density(g/cm^3)	Up to 1.5
Length	300-756
Cellulose Content (%)	81.68
Hemicellulose(%)	7.01
Lignin(%)	11.28
Diameter(mm)	0.18mm
Ash(%)	0.2
Tensile Stress(Mpa)	276-332

Preparation of Epoxy and Hardener

Epoxy LY-556 of density 1.15–1.20 g/cm3, mixed with hardener HY-951 of density 0.97–0.99 g/cm3 is used to prepare the composite. The mixing ratio of Epoxy and hardener is 10:1. Resin was purchased from M/s. Sivaram Traders, Hyderabad, A.P, India. Properties of resin were presented in the following table-2.

Table 2: Properties of Epoxy Resin

Epoxy Resin	
Density(g/cm^3)	1.16
Tensile Strength(Mpa)	39.99
Tensile modulus (GPa)	0.7-1.3
Apparent porosity (%)	0.30
Modulus of elasticity (GPa)	0.83
Stiffness(kN/mm)	10-29

Chemical Treatment

Fiber extracted from the bark of the trees is treated with 5% NaoH solution and processed. The processed fiber is dried in sunlight and in the Oven for 2hrs at 60^0 c to remove any moisture still present before going for Fabrication. Processed fiber is readily supplied by the 'Natural Fiber suppliers', Guntur, A.P, India.

Fabrication of Composites

In the present work moulds made of Glass with dimensions 150X150X3 mm are used for fabrication of Composites. Fabrication was carried out through hand lay-up technique. Initially the top and bottom surfaces of the mould are coated with removing agent and dried. A layer of epoxy mixed with the hardener is applied on the bottom surface of the mould and soon it began to dry completely a layer of fiber is placed and the process is repeated till the required thickness and weight percentage of the fiber is reached. The top surface of the mould is closed with the glass plate followed by releasing agent, compressed and allowed to dry for 24 hrs. After the curing process, test samples were cut to the required sizes prescribed in the ASTM standards.

Chemical Resistance

The chemical resistance of the test composites was studied under alkalies, acids and solvents. The Hardwickia Binata Fiber composites were immersed in chemicals according to standards ASTM D 543-87 with dimensions 10x10x3mm. Three acids, three bases and three solvents were taken for analysis. Glacial Acetic acid (8%), con. nitric acid (40%), con. hydrochloric acid (10%), con ammonium hydroxide (10%), aq. sodium carbonate (20%), aq. sodium hydroxide (10%), toluene (250ml), benzene (250ml), and carbon tetrachloride (250ml) were used after purification. In each case, the samples were pre-weighed in a precision electronic balance and dipped in the respective chemicals for 24 hours. They were removed and immediately washed in distilled water and dried by pressing them on both sides with the filter paper at room temperature. The treated samples were then re-weighed and the %weight loss/gain was determined. In each case, five samples were tested and their average values were reported.

% of variation in weight = $(w_2-w_{1)}/w_1$ X 100

Where w_1 is the weight of the specimen before immersion

w_2 is the weight of the specimen after immersion

Water Absorption

The water absorption experiment has been conducted for the composite samples. The samples were cut as per the ASTM D 5229/D 5229M-92 standards with size 20x20x3 mm and dried in an oven at 80^0C for 24 h. The dried specimens were weighed and note the weight. Then the specimens are immersed in distilled water at room temperature. The samples were taken out in the time interval of 10 hrs and weighed, after wiping off the water on the surface of the specimens samples with a cloth. The natural fibers are good examples of permeable fibers that absorb water to a much larger extent than the resin calculated by using the following equation.

% of Water absorption = $(m_2\text{-}m_1/m_1)$ X 100

Where m_2 is the weight of the specimen after immersion

m_1 is the weight of the specimen before immersion

Scanning Electron Microscopy

Interfacial properties, such as fiber–matrix interaction, fracture behavior, and fiber pull-out of samples after water absorption was observed using ZEISS scanning electron microscope. The fractured portions of the samples were cut and gold coated over the surface uniformly for examination. The accelerating voltage used in this work is 10 kV.

RESULTS AND DISCUSSIONS

Chemical Analysis

From the chemical Analysis, is observed that for acids and alkalies there is weight gain and the samples dipped in the solvents there is weight loss. The percentage variation in weight is due to hydrophilicity nature of the fiber. In these cases, the OH groups in the cellulose were better exposed and increased the hydrophilicity of the system. Also it is observed that as the fiber loading is increasing there is an increase in the percentage variation of weight. Percentage variation of weight is almost near for 15% and 20% fiber loading. For solvents it is quiet reverse i.e weight loss is observed. Maximum weight loss is observed at Toulene.

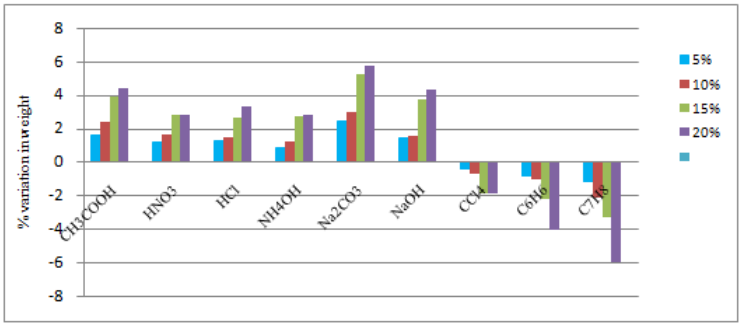

Figure 1: Chemical Absorption of different Composite Samples Varying Fiber Loading

Water Absorption

From the figure, it is confirmed that the maximum amount of water has been absorbed up to 50 hours of immersion and after that the percentage of water absorption remains constant. The swelled surface of the composite specimen and fiber swelling has been observed. Surface decomposition also takes place when the specimen immersed in

water for a long period of time.

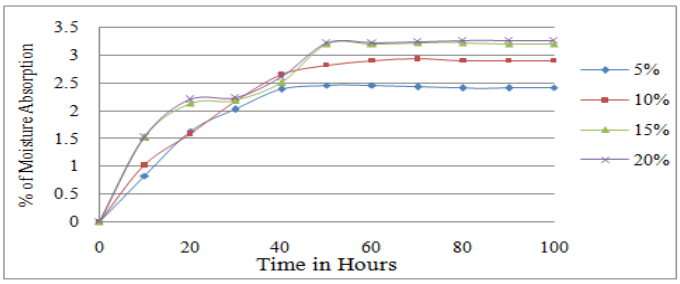

Figure: 2 Moisture Absorption of different Composite Samples varying Fiber Loading

Scanning Electron Microscopy Analysis

The micrographs of the samples after moisture absorption at constant time intervals are presented in Figure 3. The water absorbed matrix layer is clearly visible in Figure 3(a), this is confirmed that the maximum amount of water has been absorbed up to 50 hours of immersion and after that the percentage of water absorption remains constant. The swelled surface of the composite specimen and fiber swelling has been observed. Surface decomposition also takes place when the specimen immersed in water for a long period of time.

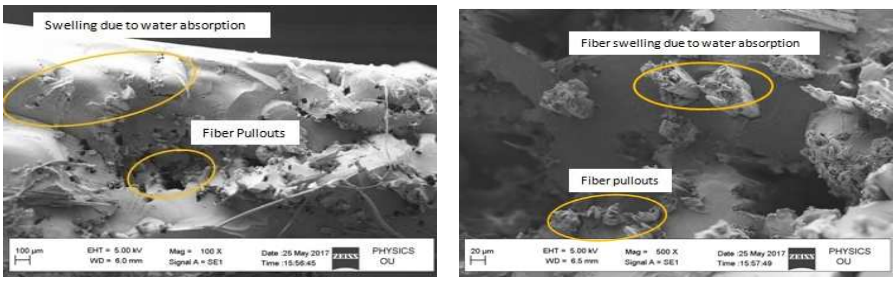

Figure 3(a) & 3(b): Microstructures of Composite Samples Immersed in Water

CONCLUSIONS

In the present investigation Hardwickia Binata fiber reinforced composites are fabricated at different fiber loadings and the following conclusions have been arrived.

- From the water absorption tests, it can be concluded that the incorporation of Hardwickia binata fiber into the Epoxy matrix is increasing simultaneously, with increase fiber content from 5% to 20% and is following Fickian behavior.
- From the chemical resistance test it is observed that the composites were found to be resistant to some acids, alkalies and solvents. Also it is concluded that percentage variation in weight is increasing as the fiber content is increasing.
- From the SEM analysis, the fiber fracture, swelling due to water absorption and the internal cracks of the fractured surfaces are clearly observed. Further it can be observed that the interfacial bonding between the fiber and matrix is good for the composite samples and the fibers are well dispersed into the matrix.

REFERENCES

1. *May-Pat, et.al, "Effect of fiber surface treatments on the essential work of Fracture of HDPE-continuous henequen fiber-reinforced composites,"Polymer Testing, vol. 32, no. 6, pp. 1114–1122, 2013.*
2. *Ticoalu, T. Aravinthan, and F. Cardona, "A review of current development in natural fiber composites for structural and infrastructure applications," in Proceedings of the Southern Region Engineering Conference (SREC '10), pp. 113–117, Toowoomba, Australia, November 2010.*
3. *A. Shalwan and B. F. Yousif, "In state of art: mechanical and tribological behaviour of polymeric composites based on Natural fibres," Materials & Design, vol. 48, pp. 14–24, 2013*
4. *Y. Xie, C. A. S. Hill, Z. Xiao, H. Militz, and C. Mai, "Silane coupling agents used for natural fiber/polymer composites: a review," Composites Part A: Applied Science and Manufacturing, vol. 41, no. 7, pp. 806–819, 2010.*
5. *H. Ku, H. Wang, N. Pattarachaiyakoop, and M. Trada, "A review on the tensile properties of natural fiber reinforced polymer Composites," Composites Part B: Engineering, vol. 42, no. 4, pp.856–873, 2011*
6. *K. Mohanty, M. A. Khan, and G. Hinrichsen, "Surface modification of jute and its influence on performance of biodegradable jute-fabric/Biopol composites," Composites Science and Technology, vol. 60, no. 7, pp. 1115–1124, 2000.*
7. *V. K. Thakur and M. K. Thakur, "Processing and characterization of natural cellulose fibers/thermoset polymer composites,"Carbohydrate Polymers, vol. 109, pp. 102–117, 2014.*
8. *M. S. Sreekala, M. G. Kumaran, and S. Thomas, "Stress relaxation behaviour in oil palm fibres,"Materials Letters, vol. 50, no.4, pp. 263–273, 2001.*
9. *B. Ren, T. Mizue, K. Goda, and J. Noda, "Effects of fluctuation of fibre orientation on tensile properties of flax sliver-reinforced green composites," Composite Structures, vol. 94, no. 12, pp. 3457–3464, 2012.*
10. *Y. Pan and Z. Zhong, "A micromechanical model for the mechanical degradation of natural fiber reinforced composites induced by moisture absorption," Mechanics of Materials, vol.85, pp. 7–15, 2015.*
11. *E. Jayamani, S. Hamdan, M. R. Rahman, and M. K. B. Bakri, "Investigation of fiber surface treatment on mechanical, acoustical and thermal properties of betelnut fiber polyester composites," Procedia Engineering, vol. 97, pp. 545–554, 2014.*
12. *L. Boopathi, P. S. Sampath, and K. Mylsamy, "Investigation of physical, chemical and mechanical properties of raw and alkali treated Borassus fruit fiber," Composites Part B: Engineering, vol.43, no. 8, pp. 3044–3052, 2012.*
13. *M. Ramesh, T. S. A. Atreya, U. S. Aswin, H. Eashwar, and C. Deepa, "Processing and mechanical property evaluation of banana fiber reinforced polymer composites," Procedia Engineering, vol. 97, pp. 563–572, 2014.*
14. *N. Venkateshwaran, A. Elaya Perumal, and D. Arunsundaranayagam, "Fiber surface treatment and its effect on mechanical and visco-elastic behaviour of banana/epoxy composite," Materials & Design, vol. 47, pp. 151–159, 2013.*
15. *Shanmugam, D., and M. Thiruchitrambalam. 2013. Static and dynamic mechanical properties of alkali treated unidirectional continuous palmyra palm leaf stalk fiber/jute fiber reinforced hybrid polyester composites. Materials & Design 50: 533–542.*
16. *B. R. Guduri,1,2 A. V. Rajulu,3 A. S. Luyt2 "Chemical Resistance, Void Contents, and Morphological Properties of Hildegardia Fabric/Polycarbonate-Toughened Epoxy Composites" Journal of Applied Polymer Science, Vol. 106, 3945–3951 (2007)*
17. *J. Jayaramudu1*, S.C. Agwuncha2, S.S. Ray1, E. R. Sadiku2, A. Varada Rajulu3 "Studies on the chemical resistance and mechanical properties of natural polyalthia cerasoides woven fabric/glass hybridized epoxy composites" Adv. Mater. Lett.*

2015, 6(2), 114-119

18. *Hardwickia binata - Species Information. 2013. The International Centre for Research in Agro forestry.*
19. *Agro forestry Database 4.0 (Orwa et al.2009)*
20. *S.K.M.Basha et.al "Ethno botanical Study of Mamandur Forest" (Kadapa- Nallamali Range) in Eastern Ghats, Andhra Pradesh, Indian Journal of Phytology 2011, 3(10): 44-47 ISSN: 2075-6240*